GOES-R AWG Product Validation Tool Development

Snow Cover Team

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OUTLINE

- **Products** (1-2 slides)
- **Validation Strategies** (3-4 slides)
- **Routine Validation Tools** (4-5 slides)
- **"Deep-Dive" Validation Tools** (4-5 slides)
- **Ideas for the Further Enhancement and Utility of Validation Tools** (1-2 slides)
- **Summary**

Requirements

Product	*Accuracy (e_c> 0.8)*	*Precision (e_c >0.8)*	*horizontal resolution*
Snow Cover (present, erroneous)	30%	15%	
Snow Cover (corrected)	15%	30%	

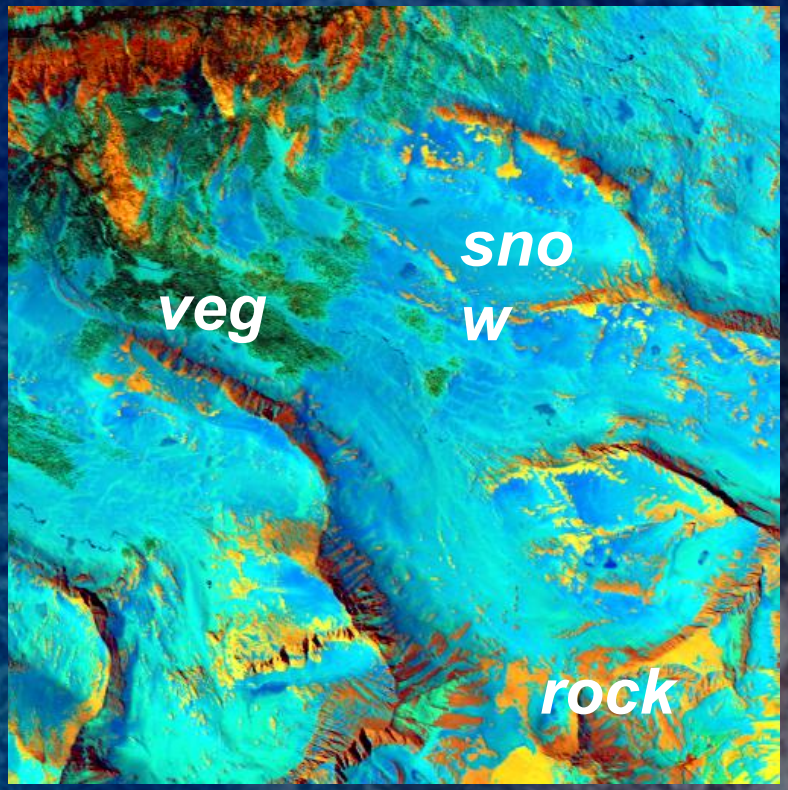
Algorithm Motivation

The pixel radiance from the surface that reaches the sensor is a mixture of contributions of radiances from snow, vegetation, soils, lake ice, etc.

This scene is from the Sierra Nevada with 17 m imaging spectrometer data with the vast majority of radiances within a single pixel coming from a single surface.

2 km

2 km

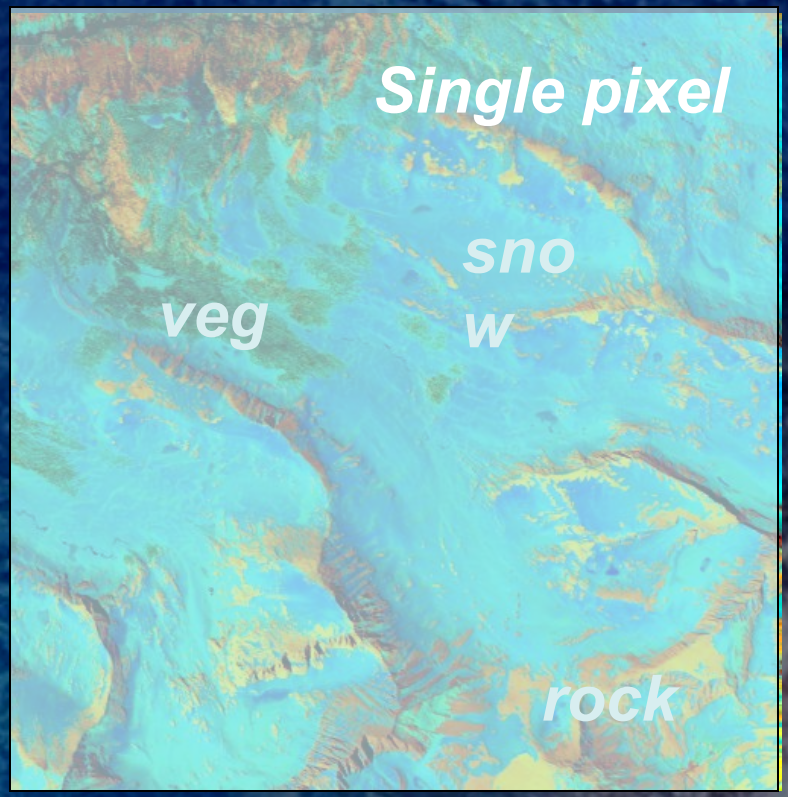


AVIRIS

Algorithm Motivation

The pixel radiance from the surface that reaches the sensor is a mixture of contributions of radiances from snow, vegetation, soils, lake ice, etc.

In this case, a single GOES-R ABI pixel is presented showing the underlying mixture of radiances from snow, vegetation, and exposed rock



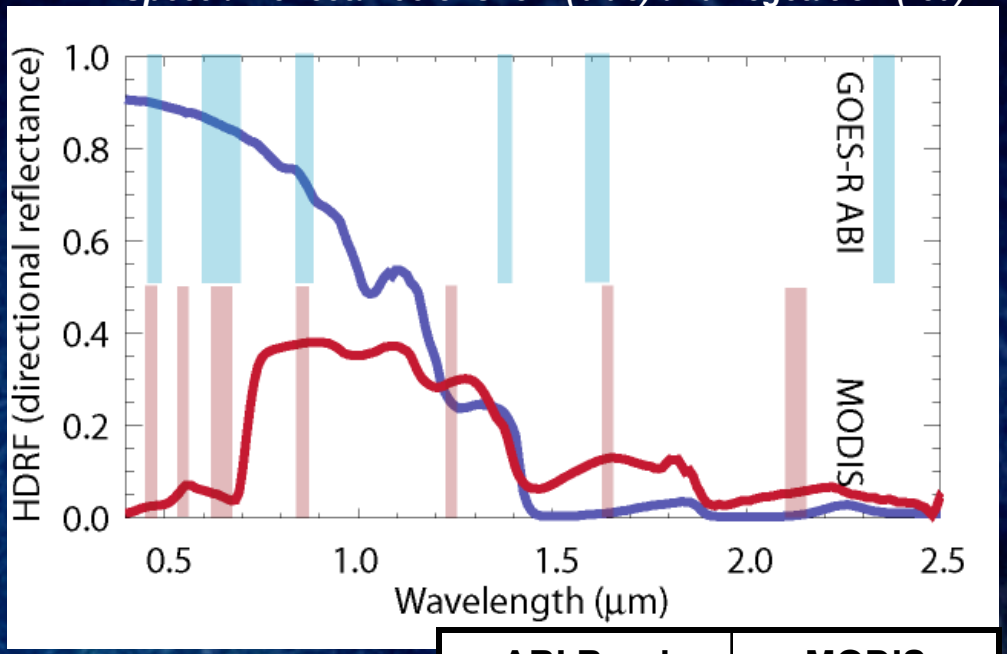
Snow Cover Algorithm

$$\overline{R_\lambda} = \sum_{i=1}^{N} F_i R_{\lambda i} + \varepsilon_\lambda$$

$$\varepsilon_\lambda = \overline{R_\lambda} - \sum_{i=1}^{N} F_i R_{\lambda i}$$

$$RMSE = \sqrt{\frac{1}{M}\sum_{\lambda=1}^{M} \varepsilon_\lambda^2}$$

Spectral reflectance of snow (blue) and vegetation (red)

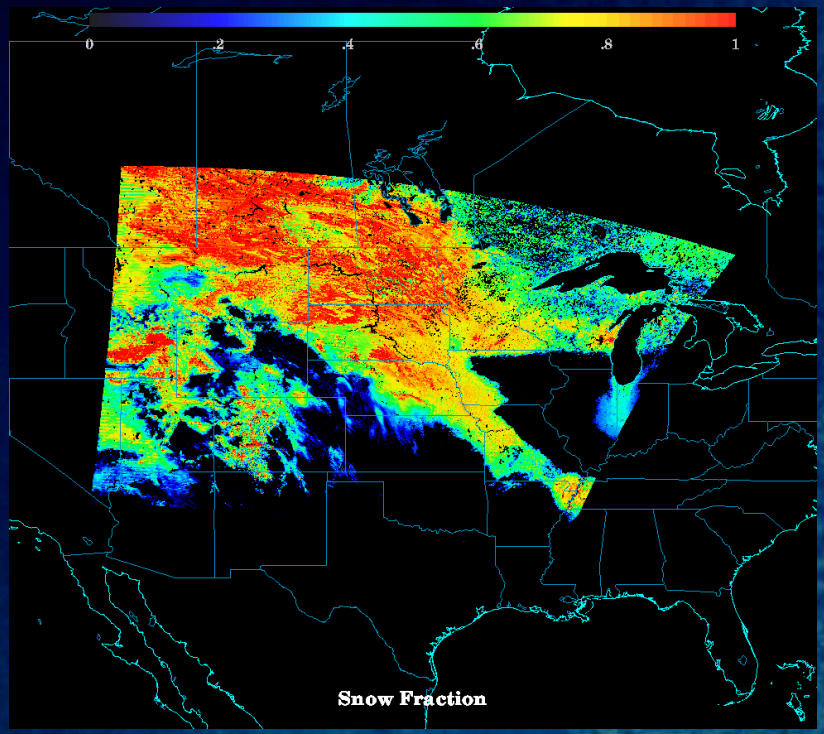


ABI Band	MODIS Proxy
1	1
2	3
3	4
5	6
6	7

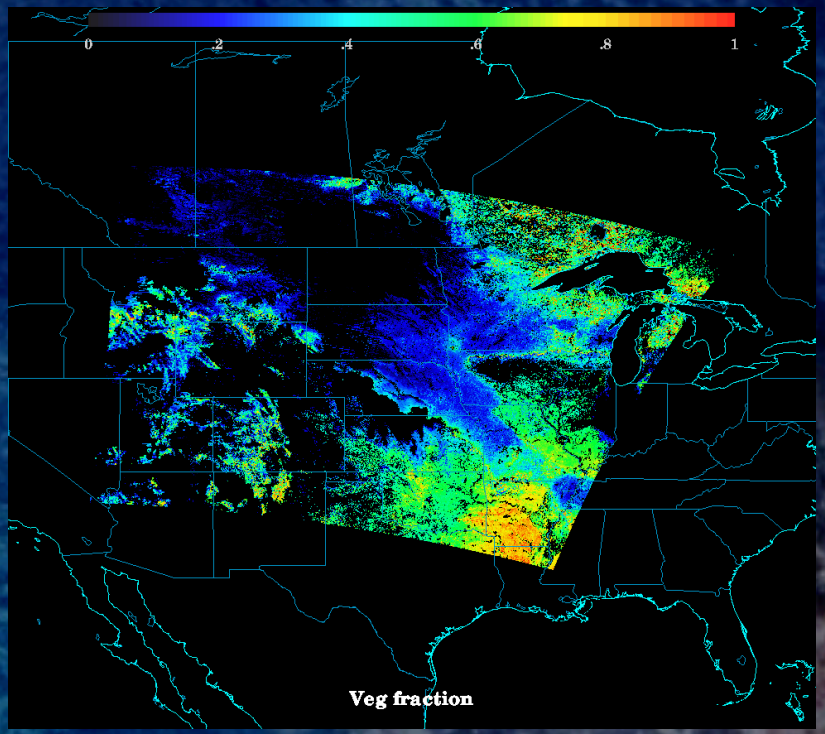
GOESRSCAG spectrally unmixes allowing numbers of endmembers and the endmembers themselves to vary on a pixel by pixel basis. R is surface reflectance, N is the number of endmembers, M is the number of spectral bands, and F is the coefficient (fraction) determined from the Modified Gram-Schmidt Orthogonalization

Snow Cover Products

Fractional Snow Cover



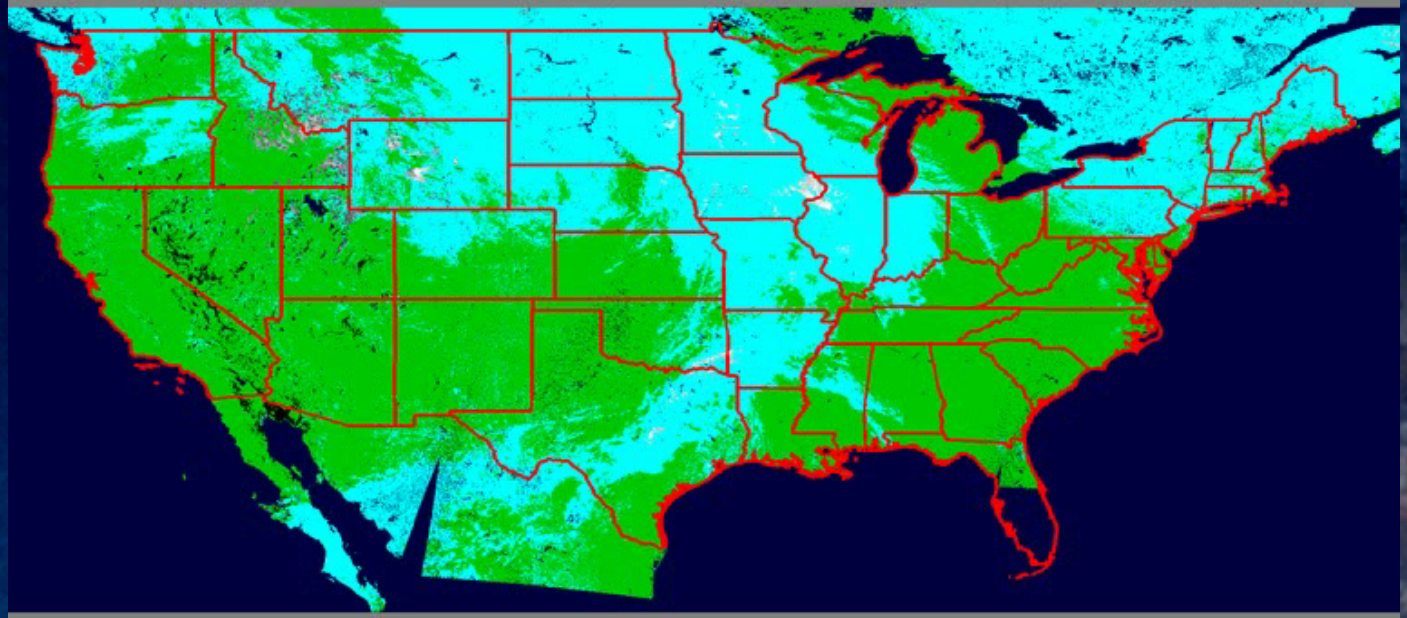
Fractional Vegetation Cover



Simulated GOES-R ABI Snow Fraction (left) and Green Vegetation Fraction (right) from GOESRSCAG processing of proxy ABI data from MODIS, March 1, 2009.

Example FSC Output

Winter/Spring 2010



Validation Strategies

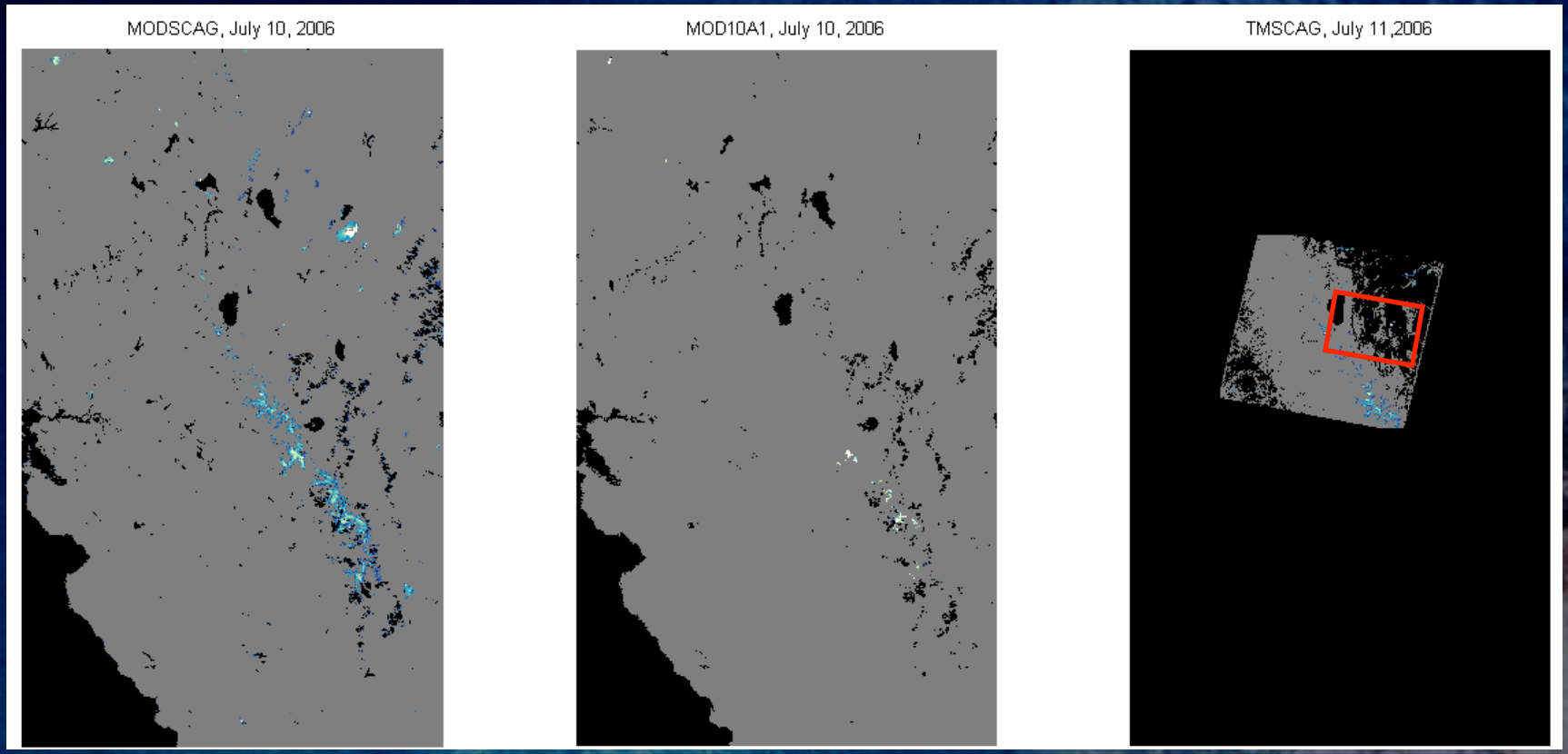
- Routine Validation
  - Validate FSCA scene-to-scene stability
  - Validate against 7-band MODIS FSCA
  - Validate against Landsat-based FSCA
  - Validate against in situ measurements and NOHRSC real time energy- and mass-balanced, spatially- and temporally-distributed snow model (CONUS only)

Validation Strategies

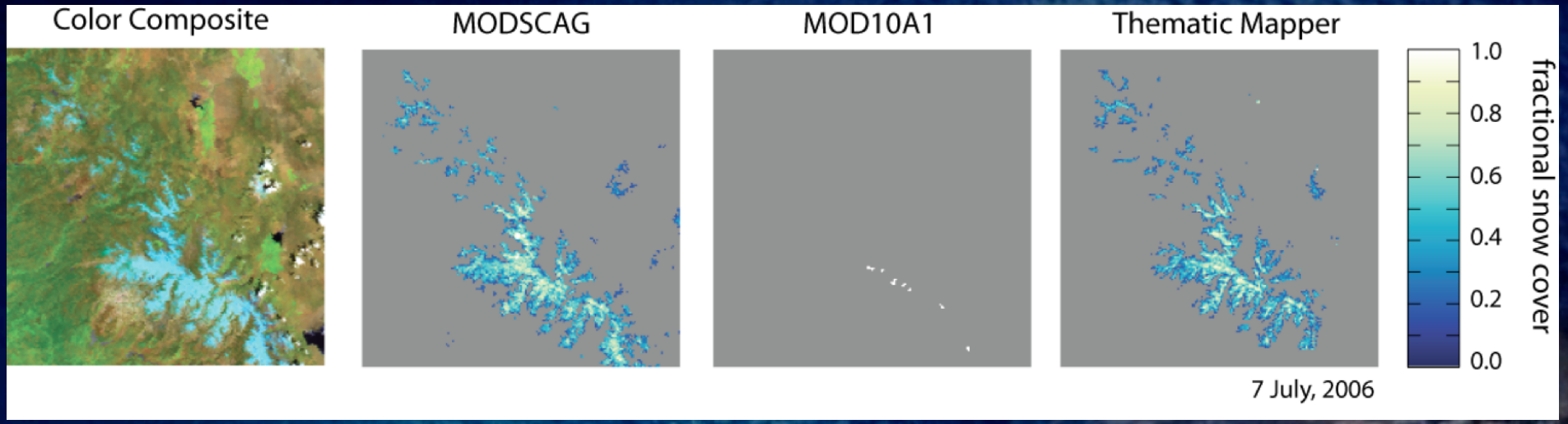
- Deep Dive Validation
  - Track significant clusters of high RMSE pixels by snow regions
  - Calculate row-column position of cluster centroid
  - Log and send email to operator if clusters found
  - Modify the FSCA to operate on a single pixel, defined by a row and column position
    - Provide verbose diagnostic information when executed in this mode

Routine Validation Tools

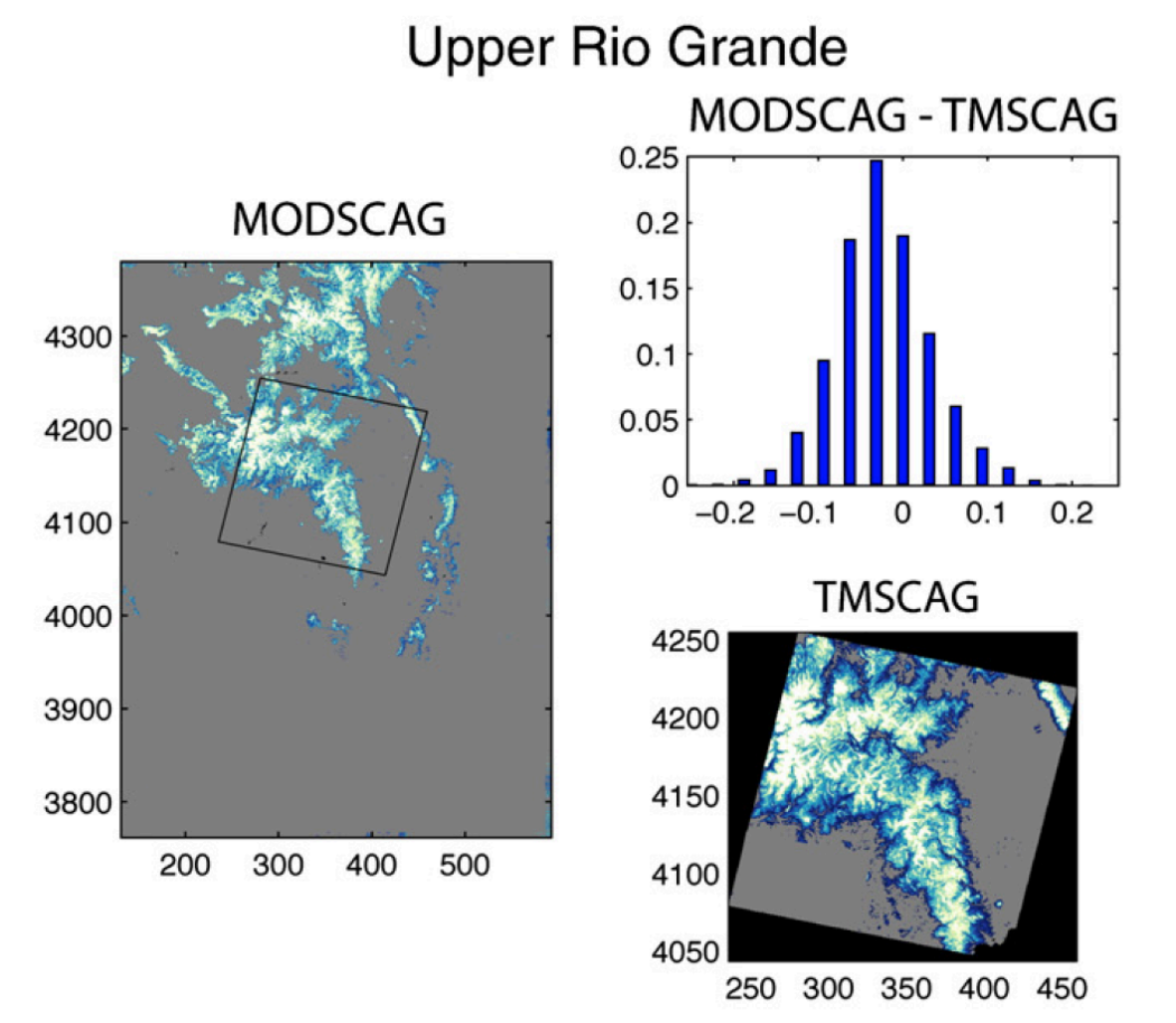
High spatial resolution validation



Routine Validation Tools



Routine Validation Tools

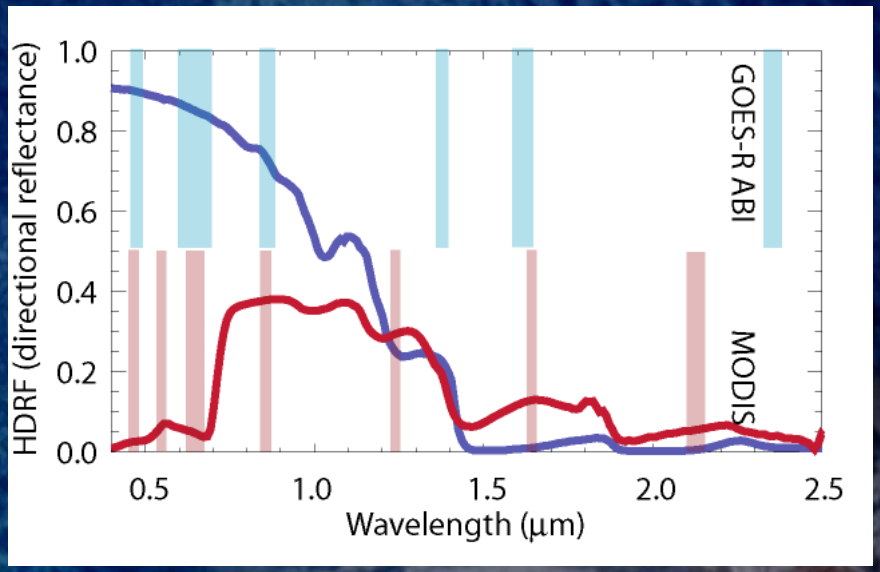


Routine Validation Tools

Proxy data validation

Goes-R ABI Channel Number	GOES-R ABI Wavelength (µm)	MODIS Proxy Band Number	MODIS Wavelength (µm)
1	0.45 – 0.49	3	0.459-0.479
2	0.59 – 0.69	1	0.620-0.670
3	0.85 – 0.88	2	0.841-0.876
5	1.58 – 1.64	6	1.628-1.652
6	2.22 – 2.28	7	2.105-2.155

Testing and validation of the GOES-R FSC algorithm is conducted using MODIS data as proxy for GOES-R ABI data



Spectral reflectance of snow (blue) and vegetation (red)

Routine Validation Tools

Remote Sensing of Environment 113 (2009) 868–879

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journal homepage: www.elsevier.com/locate/rse

Retrieval of subpixel snow covered area, grain size, and albedo from MODIS

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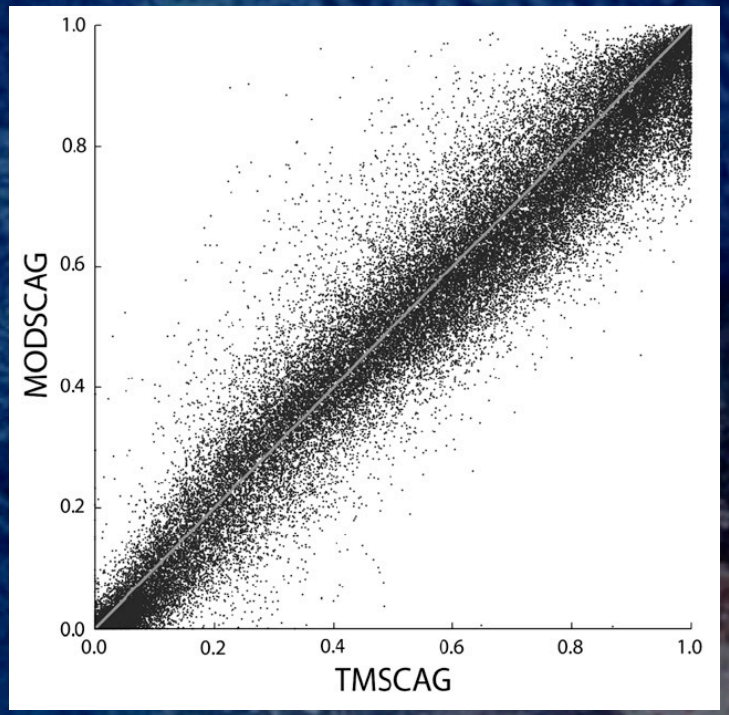
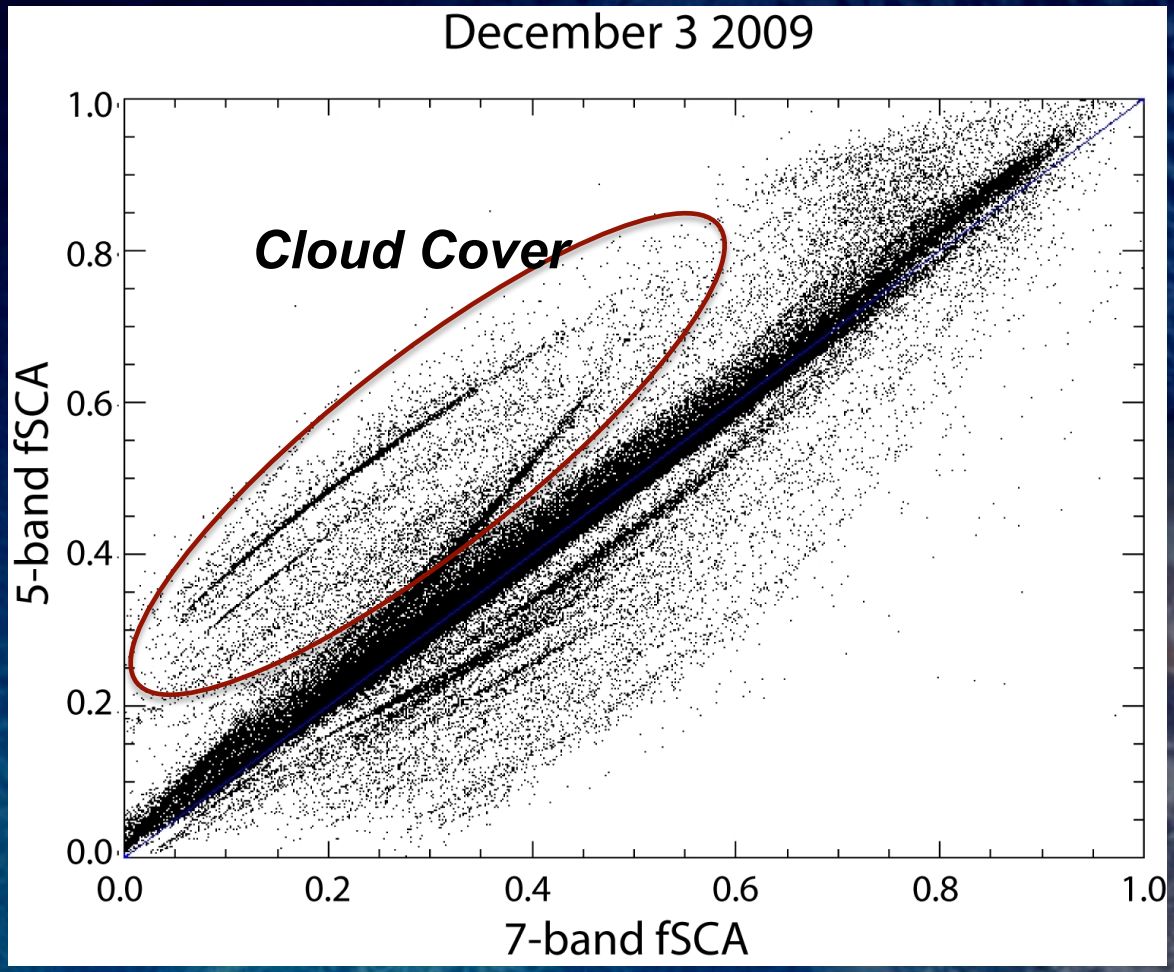


MODSCAG validation with high spatial resolution Thematic Mapper data.

Accuracy: -0.5% (w/ 0's) to -1.0% (just snow)

Precision: 4.9% (w/ 0's) to 8.9% (just snow)

Routine Validation Tools



Validation Results Summary

Validation Configuration	Accuracy (spec)	Precision (spec)
Fractional Snow Cover MODSCAG vs. Landsat (snow only)	-1.0% (15%)	8.9% (30%)
Fractional Snow Cover MODSCAG vs. Landsat (snow and snow-free)	-0.5% (15%)	4.9% (30%)
Fractional Snow Cover 5 band vs. 7 band ABI proxy (snow only)	3.7% (15%)	11.9% (30%)
Fractional Snow Cover 5 band vs. 7 band ABI proxy (snow and snow-free)	2.3% (15%)	7.7% (30%)

Pre to Post Launch Validation

In near launch and post-launch of GOES-R, Terra and Aqua MODIS are likely to have experienced partial if not complete failures. At that time, NPOESS and NPP VIIRS (Visible Infrared Imaging Radiometer Suite) data should be available.

These will supplant MODIS as proxy data for ABI and in bridge temporal validation of the FSC product.

Goes-R ABI Channel Number	GOES-R ABI Wavelength (μ m)	Used in FSC	MODIS Proxy Channel	VIIRS Proxy Channel
1	0.47	✓	1	M3
2	0.64	✓	3	M5
3	0.86	✓	4	M7
4	1.38			
5	1.61	✓	6	M10
6	2.26	✓	7	M11

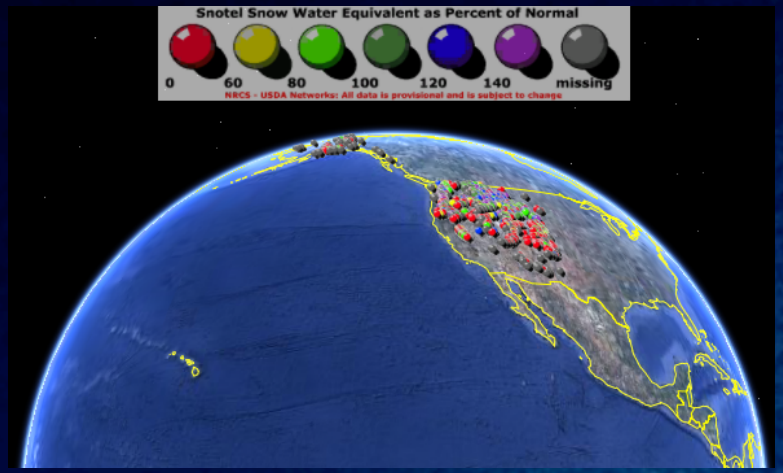
From GOES-R ABI Snow Cover Validation Plan (2009)

Pre to Post Launch Validation

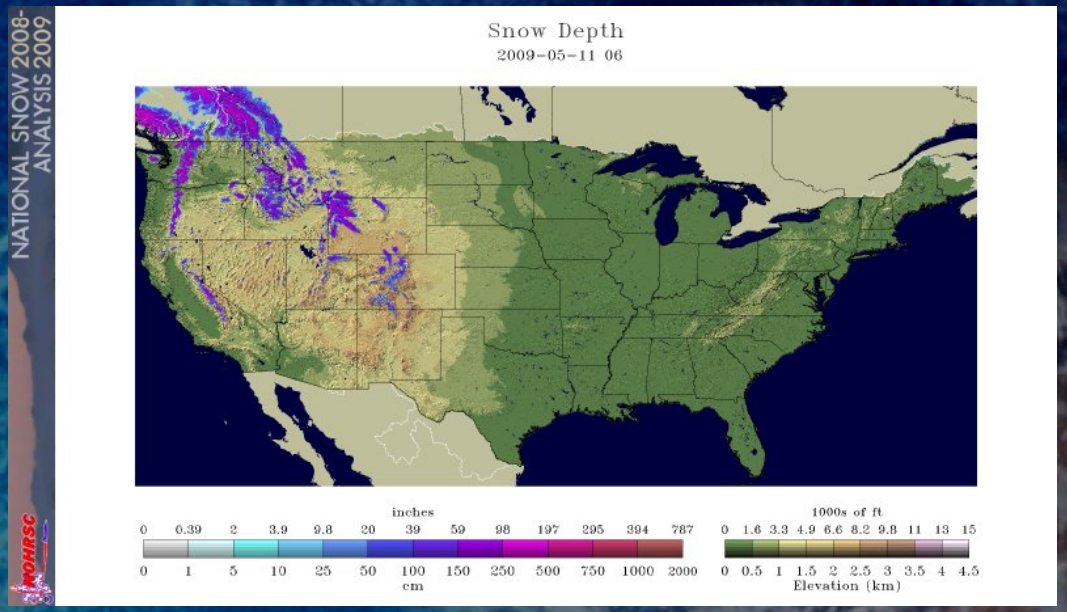
The Landsat Data Continuity Mission (LDCM) is scheduled to be launched in December 2011.

These data will be used for validation of GOES-R ABI Snow Cover in pre-launch (proxy ABI data) and post-launch (ABI data) for high resolution validation.

Post-Launch Validation



NRCS Snow Telemetry (SNOTEL) sites.



NWS NOHRSC Snow Data Assimilation System (SNODAS)

Deep-Dive Validation

Detection of High RMSE Regions

Step 1: Define or Determine a threshold value, $RMSE_T$

- Take $RMSE_T$ as program input
- Determine $RMSE_T$ From Image Avg. RMSE and StdDev

Step 2: Search image for high RMSE regions

- Perform a linear search through image to find pixels, RMSE > $RMSE_T$
- When RMSE >= $RMSE_T$, check 8 neighboring pixels
- Continue to spiral outward checking neighbors of neighboring pixels until RMSE < $RMSE_T$
- Map a spatial region $RMSE_S$, consisting of pixels with RMSE < $RMSE_T$

Deep-Dive Validation

Detection of High RMSE Regions (continued)

Step 3: Calculate Centroid

- Use geometry to solve Centroid position of $RMSE_S$
- Output position of $RMSE_S$ Centroid as (row, column) pair

Step 4: Notify operator that High RMSE Regions have been found

- Send Email/Text
- Provide direct output in terminal or a log file
- Produce trinary maps of high RMSE regions
  - 0 = RMSE < $RMSE_T$
  - 1 = RMSE >= $RMSE_T$
  - 2 = $RMSE_S$ Centroid

Deep-Dive Validation

Deep Dive Diagnostic Ability

- Provide Run-Time option to output verbose details about FSCA computational path
- Use verbose diagnostic mode to closely inspect $RMSE_S$
- Default mode: provide verbose diagnostics on $RMSE_S$ Centroid
- Other modes:
  - Inspect random pixel in $RMSE_S$
  - Inspect user-defined pixel in $RMSE_S$; boundary positions may be of interest

Ideas for the Further Enhancement and Utility of Validation Tools

- Remaining issue is the interaction between the Snow Cover and the Cloud team. Our current understanding is that the Cloud team plans to use IMS for its snow cover indicator as opposed to an interactive, refined snow/cloud discrimination.
- This is critical for meaningful validation, particularly in the ramp up to launch and operation.

Summary

- Preliminary validation indicates Snow Cover algorithm well within accuracy and precision specifications
- Routine Validation tools well established or will be adaptable when new instrumentation comes online
- Deep-Dive Validation tools framed and will be developed in this year
- Snow/cloud potential ambiguity is critical to validation for both teams